Carbon Capture and Storage in the Southwestern United States

The Southwest Regional Partnership on Carbon Sequestration

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Energy & Geoscience Institute

University of Utah

EGI Snapshot

- A cost-shared laboratory with 70 EGI scientists & staff
- Largest Univ. petroleum research consortia in world (58 members from 20 countries)
- EGI scientists worked on all 7 continents in 62 countries and produced over 500 research reports
- Cooperation with > 40 International Organizations
- Delivered > $250 Million dollars of research

58 EGI Petroleum Industry Corporate Associate Members

Anadarko - KMG
Anzon Energy
Apache
British Gas
BHPBilliton
BP
BPC Ltd.
Centrica
CEPSA
Chevron
Cobalt International
ConocoPhillips
Devon
DNO
El Paso
EnCana
Eni
Frontera
Gaz de France
Hess
Hunt Oil
Lukoil
Lundin
Maersk Oil
Marathon
Mitsui
Murphy Oil
Nations Energy
Newfield
Nexen
Nippon
Noble Energy
Norsk Hydro
Occidental
Oil Search
Oil India
OMV
Petrobras
Petronas
Petro-Canada
Pioneer
Pogo
Premier Oil
Reliance
Repsol YPF
ROC Oil
RWE Dea
Samson
Shell
Sipetrol
Statoil
Talisman
Teikoku Oil
Terralliance
Total
Tullow
Wintershall
Woodside

Member Companies -20 Countries

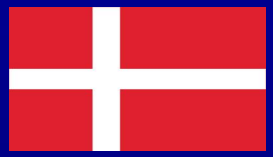

Australia

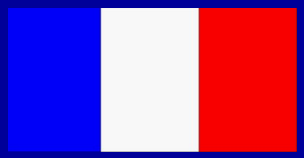

Austria


Brazil


Canada


Chile

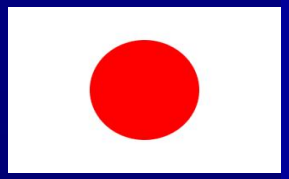

Denmark


France


Germany

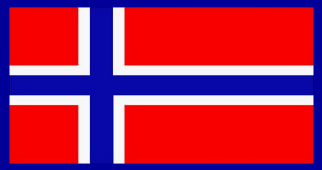

India


Italy


Japan


Malaysia


Netherlands

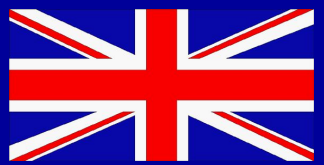

Norway

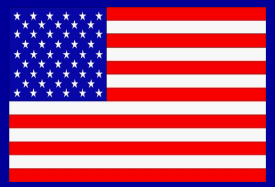

Papua New Guinea


Russia


Spain

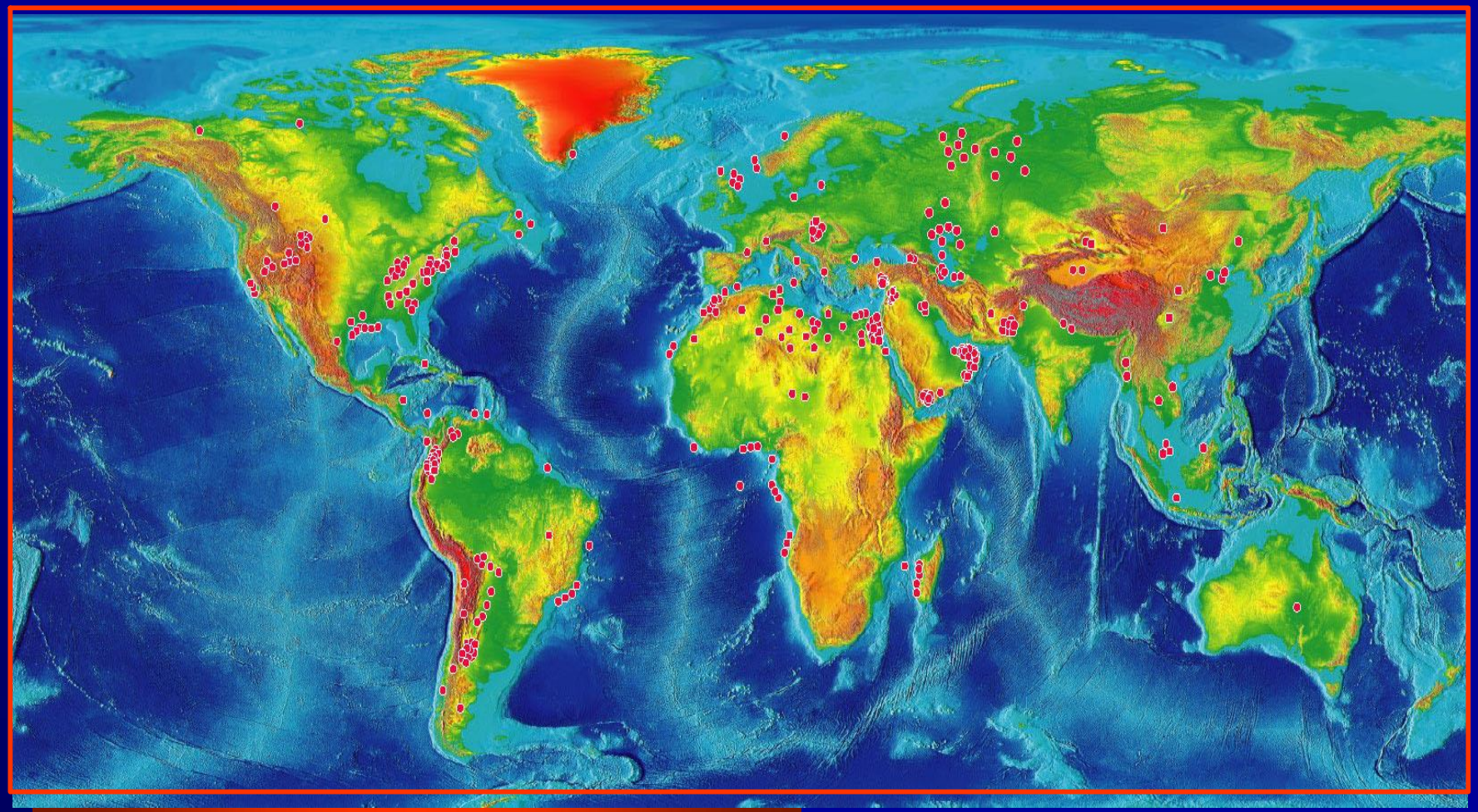

Sweden


U.K.


United States

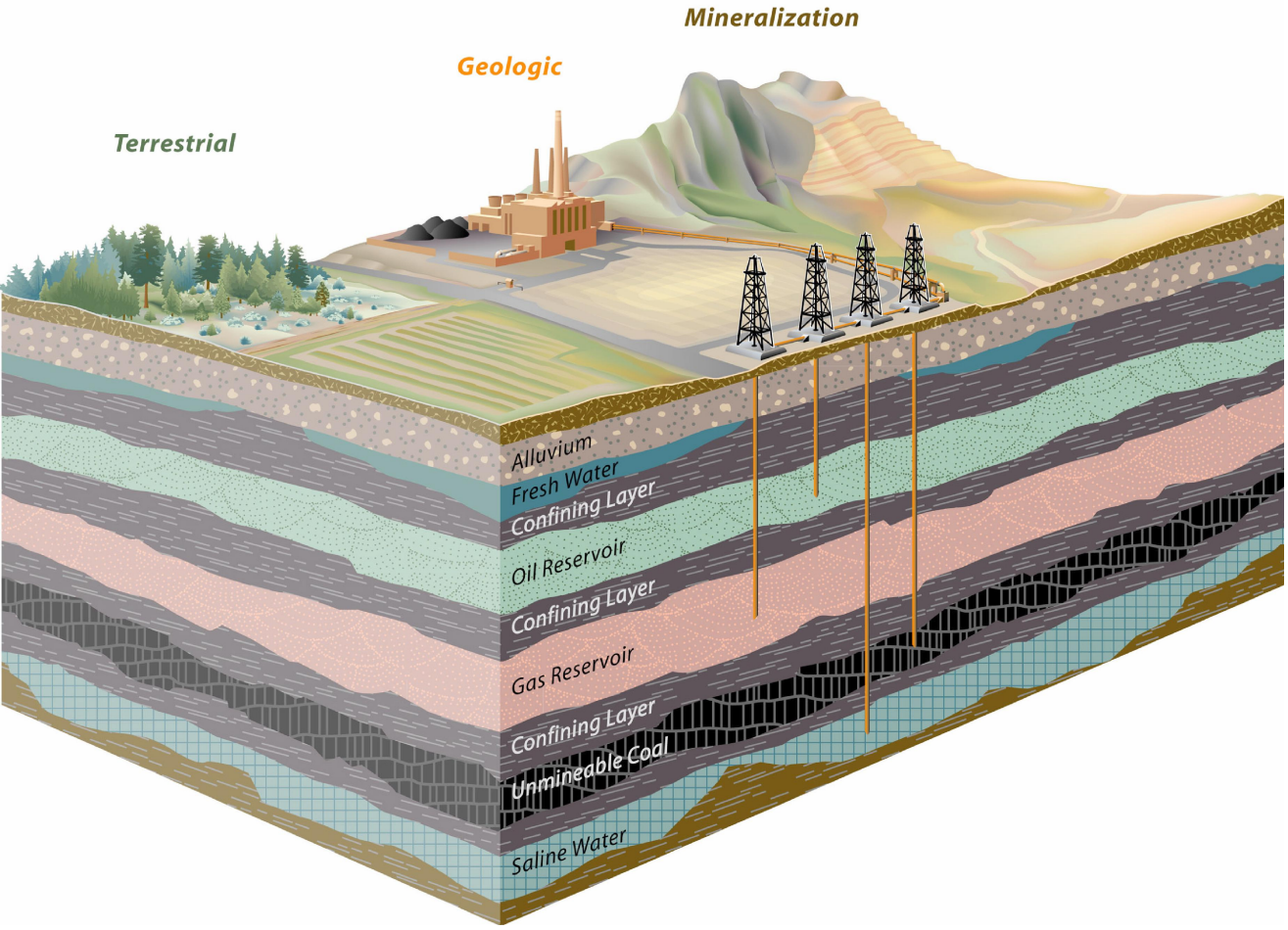
EGI is largest upstream supported consortia program at any University!

EGI Research 500+ reports in 62 Countries over 34 Years EGI



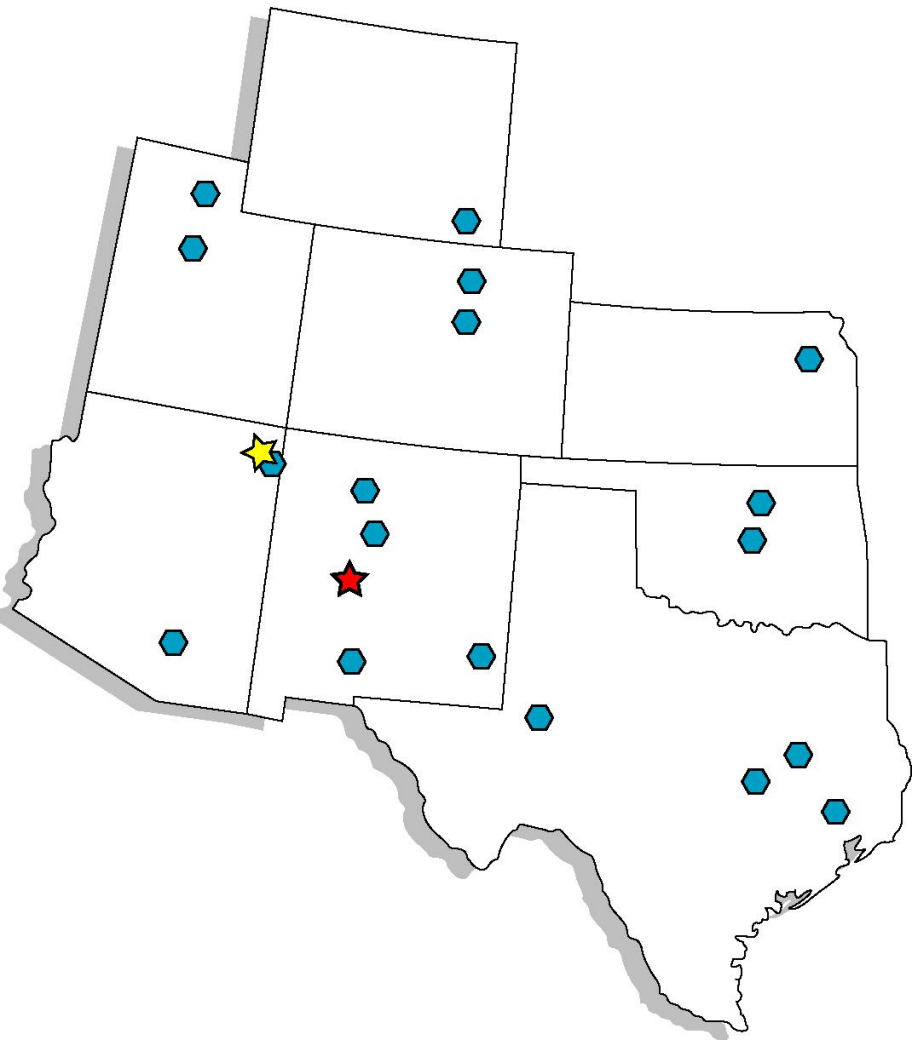
- EGI Reports available to members only

Partnership Purpose



The purpose of the Partnerships is to identify and demonstrate the most effective options for carbon sequestration.

Southwest Partners



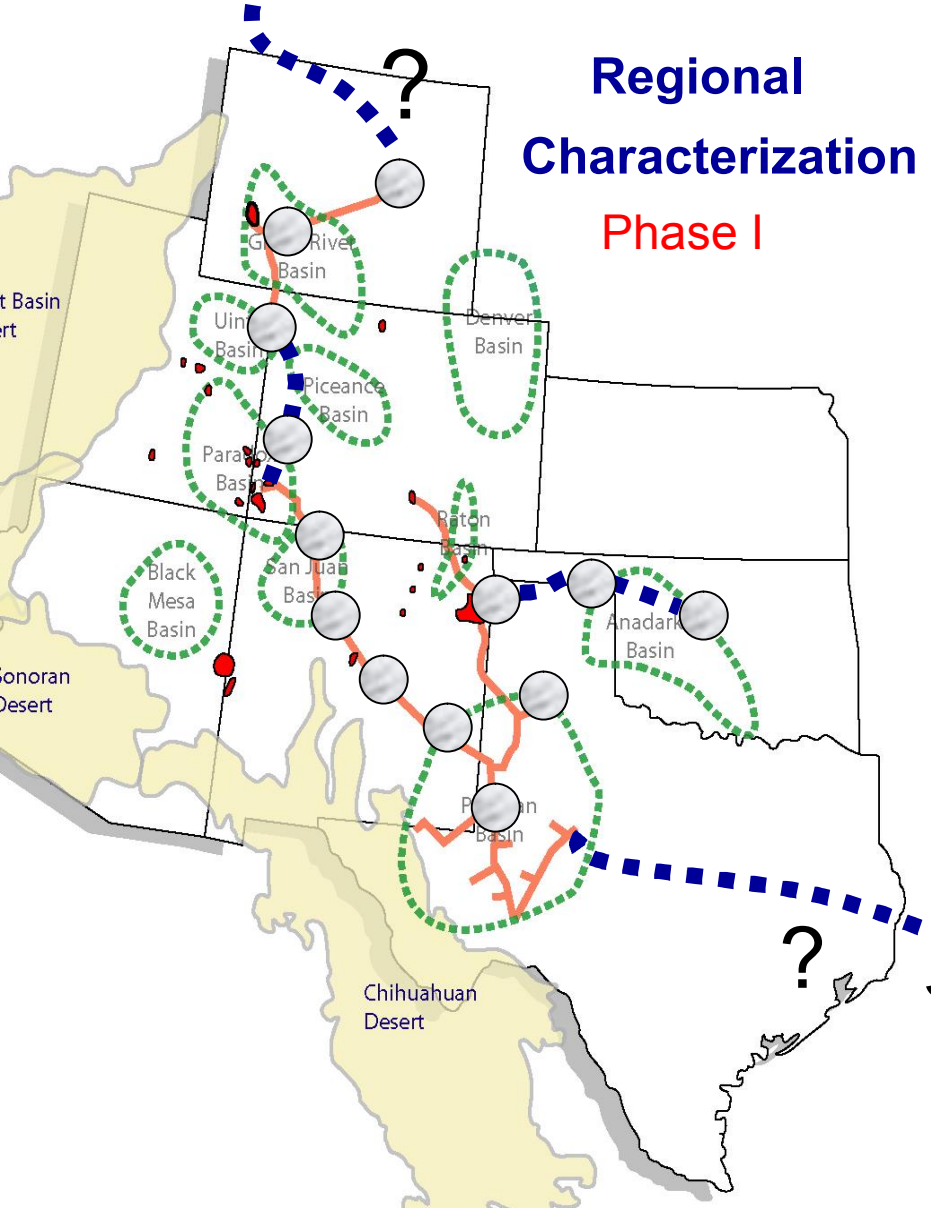
In all partner states:

- major universities
- geologic survey
- other state agencies

as well as

- Western Governors Association
- five major utilities
- seven energy companies
- three federal agencies
- the Navajo Nation
- many other critical partners

Regional Partnerships: Three Phase Work Plan



Regional Characterization
Phase I

Pilot Demos
Phase II

Full-Scale Deployment
Phase III

Southwest Theme:
"String of Pearls"

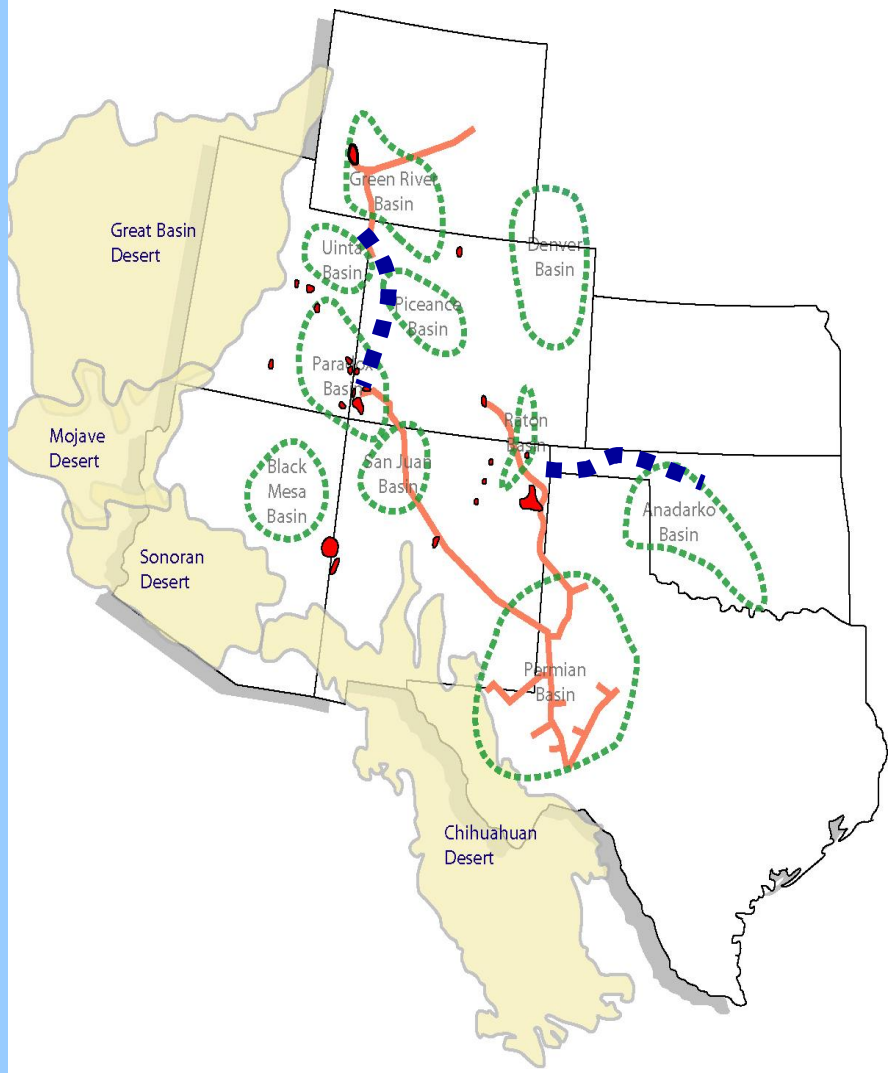
Pilot demonstrations will test short-term strategy:
sequester along pipelines

Phase I: Characterization

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008



Phase I Primary Tasks:

- Determine most effective sequestration technologies for the region
- Characterize SW region sources and sinks – develop National Atlas
- Identify the best options by tying sources to sinks
- Outcome: In SW, practical "first opportunities" lie along existing CO_2 pipelines

Phase I:
2003-2005

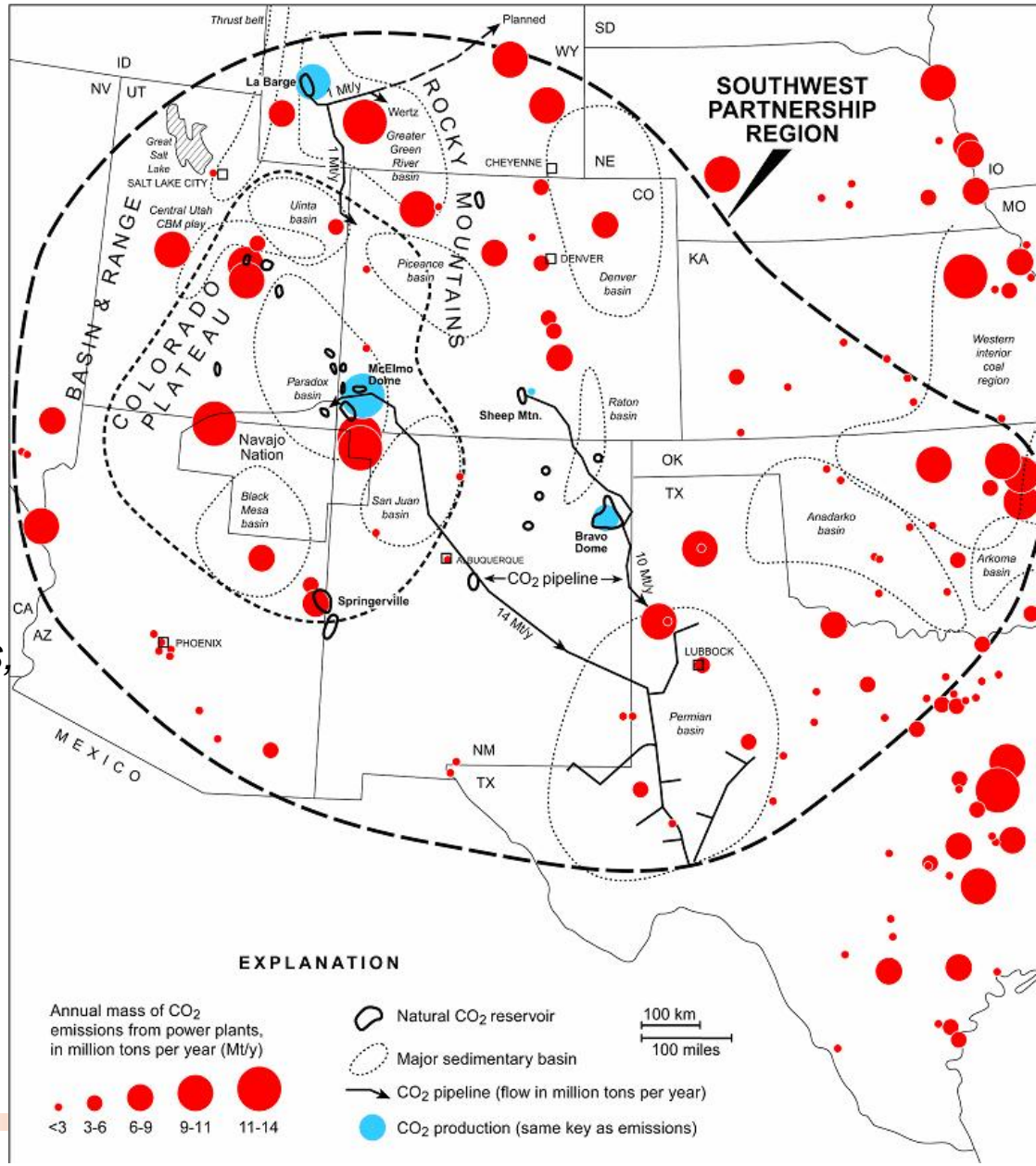
Phase II:
2005-2009

Phase III:
Start 2008

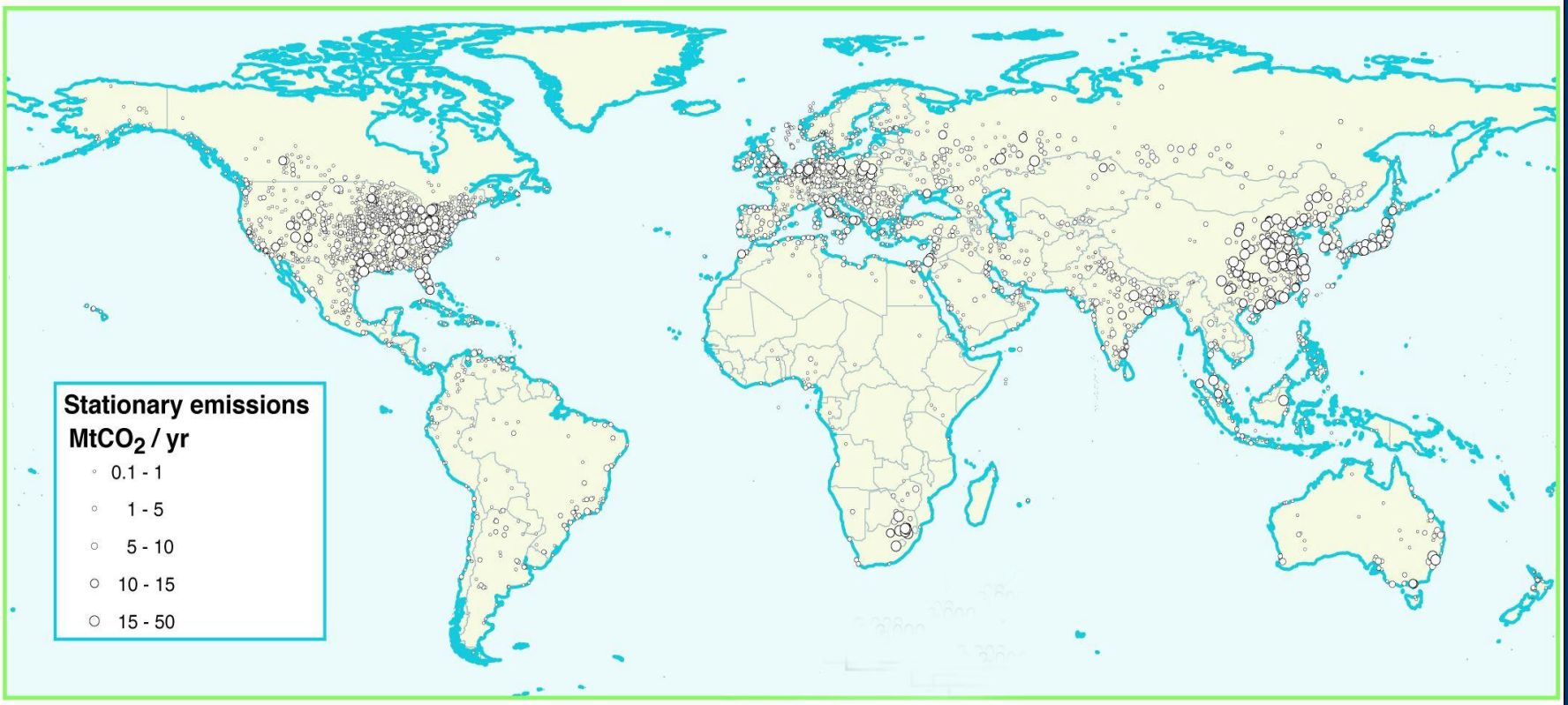
Southwest Sources and Pipelines

- *electrical power plants*
- *cement & other plants*
- *urban centers*
- *non-point sources (agriculture, automobiles, etc.)*

Total regional point source emissions Over 350,000,000 tons/year

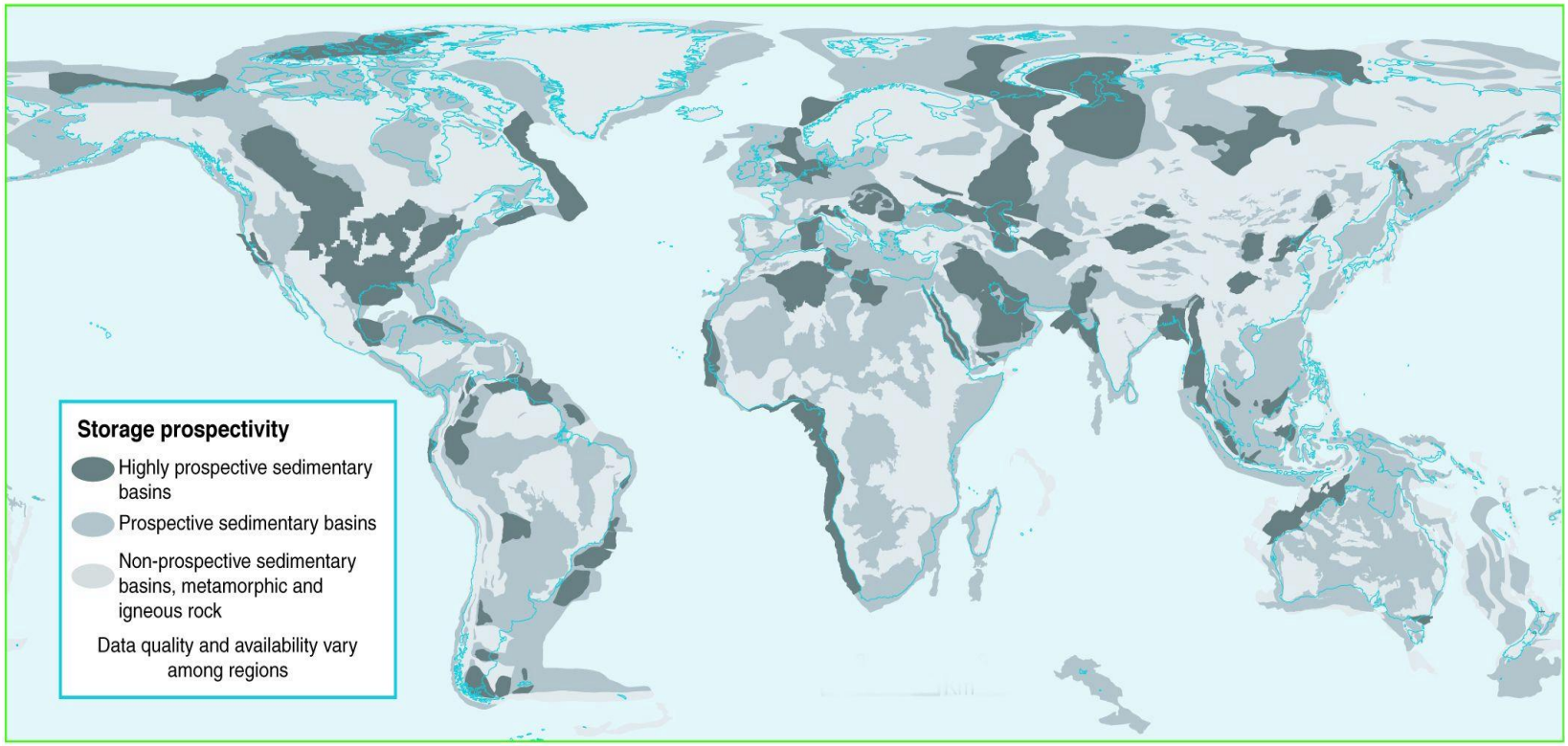


Global distribution of large stationary sources of CO2



SRCCS Figure TS-2a

Prospective areas in sedimentary basins where suitable saline formations, oil or gas fields, or coal beds may be found.



SRCCS Figure TS-2b

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Southwest CO_2 Sinks

Minimum Oil/Gas Field Capacities:

Arizona 7 Mtons

Colorado 1.7 Gtons

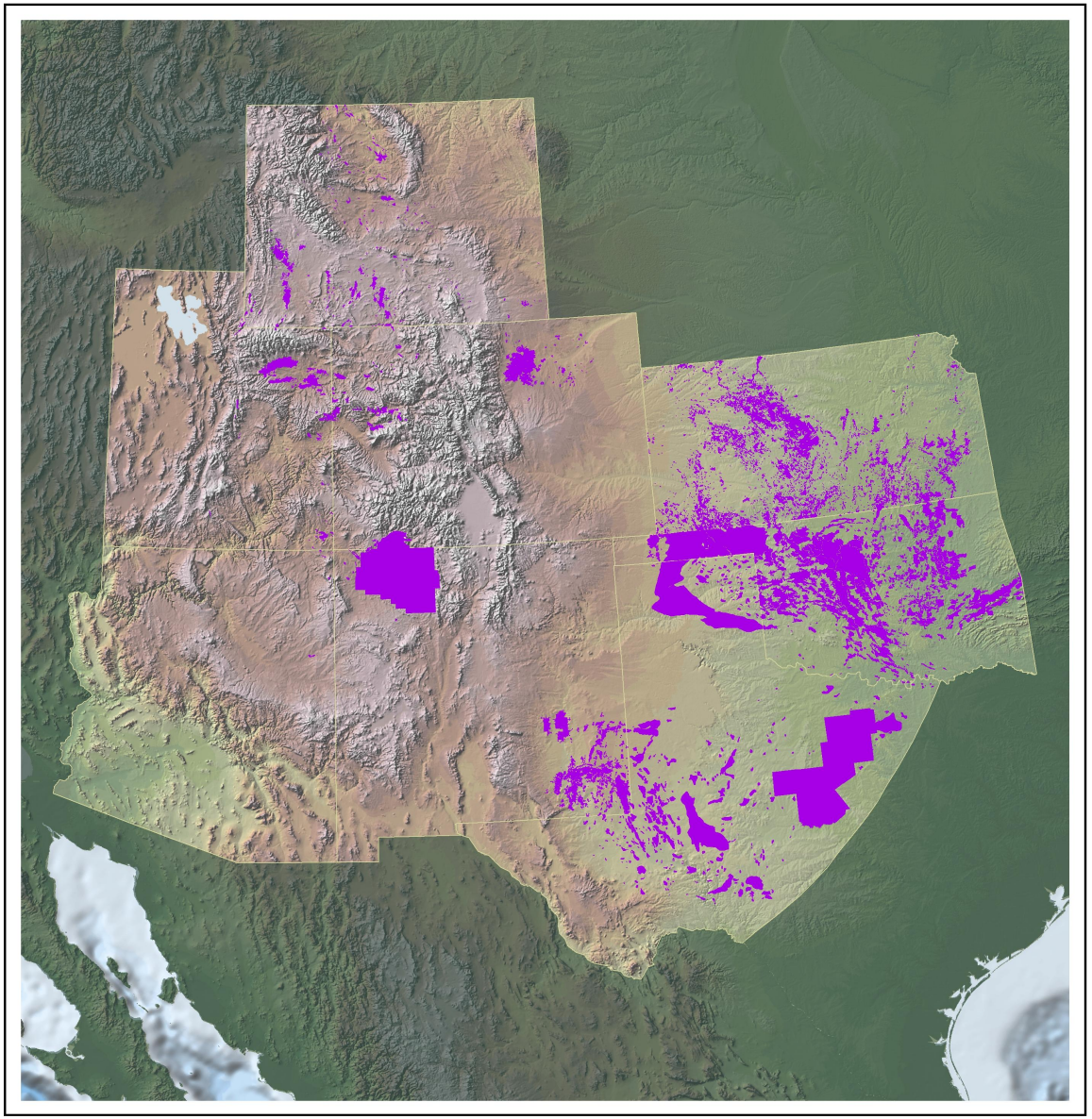
Kansas 377 Mtons

New Mexico 8 Gtons

Oklahoma 10 Gtons

Utah 1.4 Gtons

Southwest Region Oil and Gas Formations



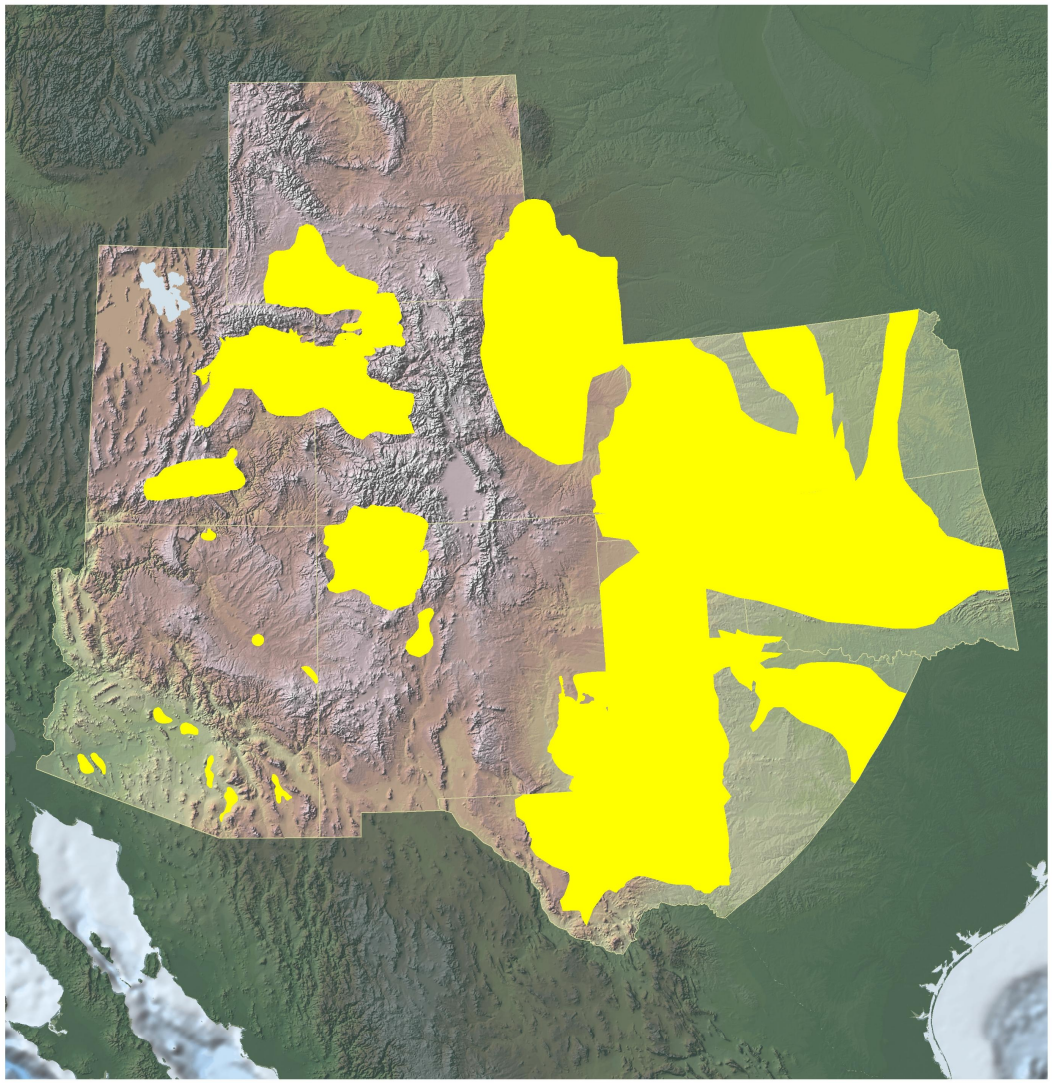
Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Southwest CO_2 Sinks

Southwest Region Saline Formations



Minimum Deep Saline Field Capacities:

Arizona 92 Mtons

Colorado 3.8 Gtons

Kansas 10.6 Gtons

New Mexico 10 Gtons

Oklahoma 9 Mtons

Texas 48 Gtons

Utah 508 Mtons

Wyoming 507 Mtons

Example of Sink-Source Comparison: Utah

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Sources (millions of tons per year):

Power and Cement Plants – under 40

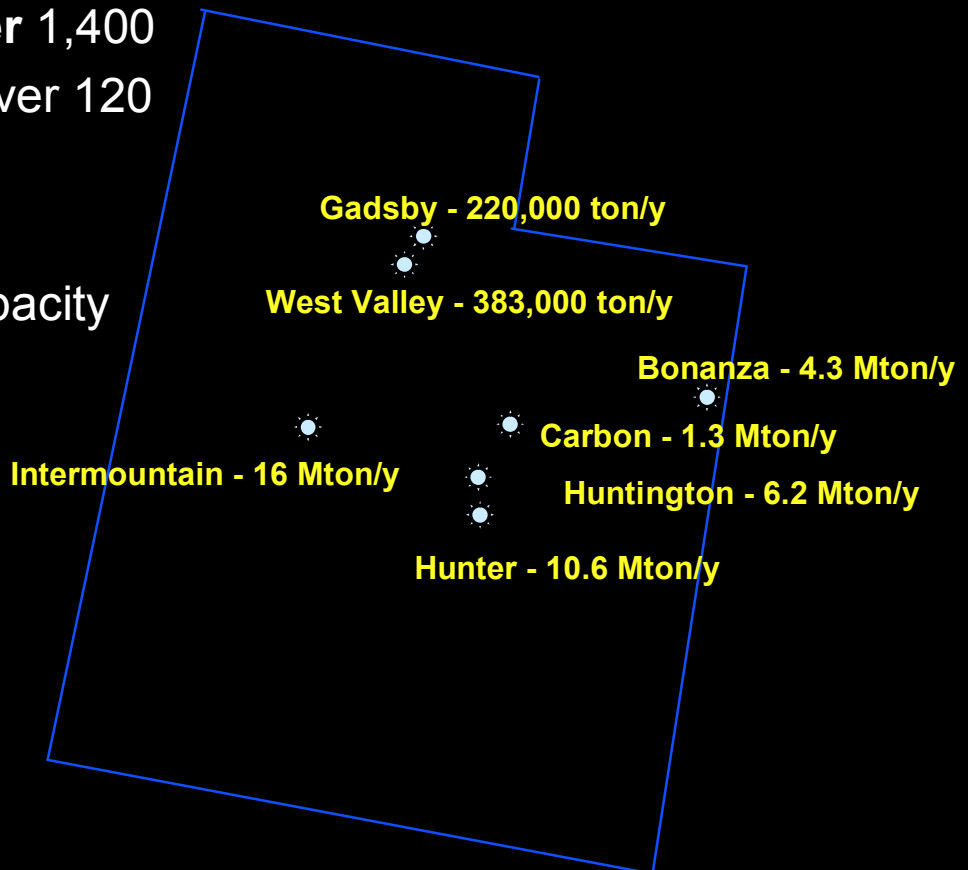
Sink Capacities (millions of tons):

Oil and Gas Reservoirs – over 1,400

Un-mineable Coal Seams – over 120

Deep Saline – over 500

Thus, the minimum storage capacity in Utah is equivalent to over 50 years of its emissions!



Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Phase II: Validation

Goals include:

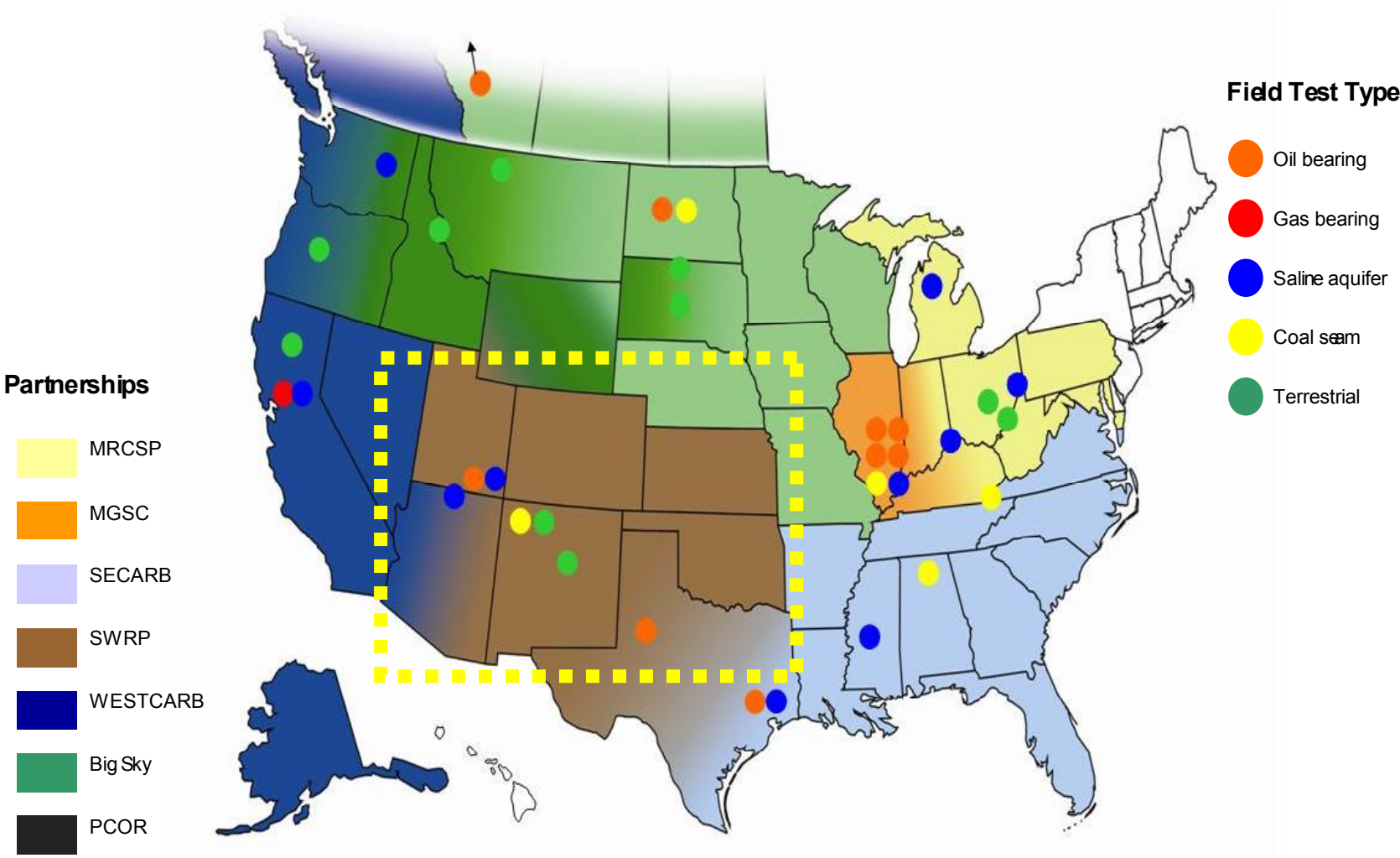
- **Perform regional technology validation tests for 2012 technology assessment**
- **Refine and implement monitoring, mitigation and verification (MMV) protocols**
- **Continue regional characterization**
- **Regulatory compliance activities**
- **Implement public outreach and education**
- **Identify commercially available sequestration technologies ready for large scale deployment**
- **Regional partnerships program integration**

Southwest Phase II Portfolio

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

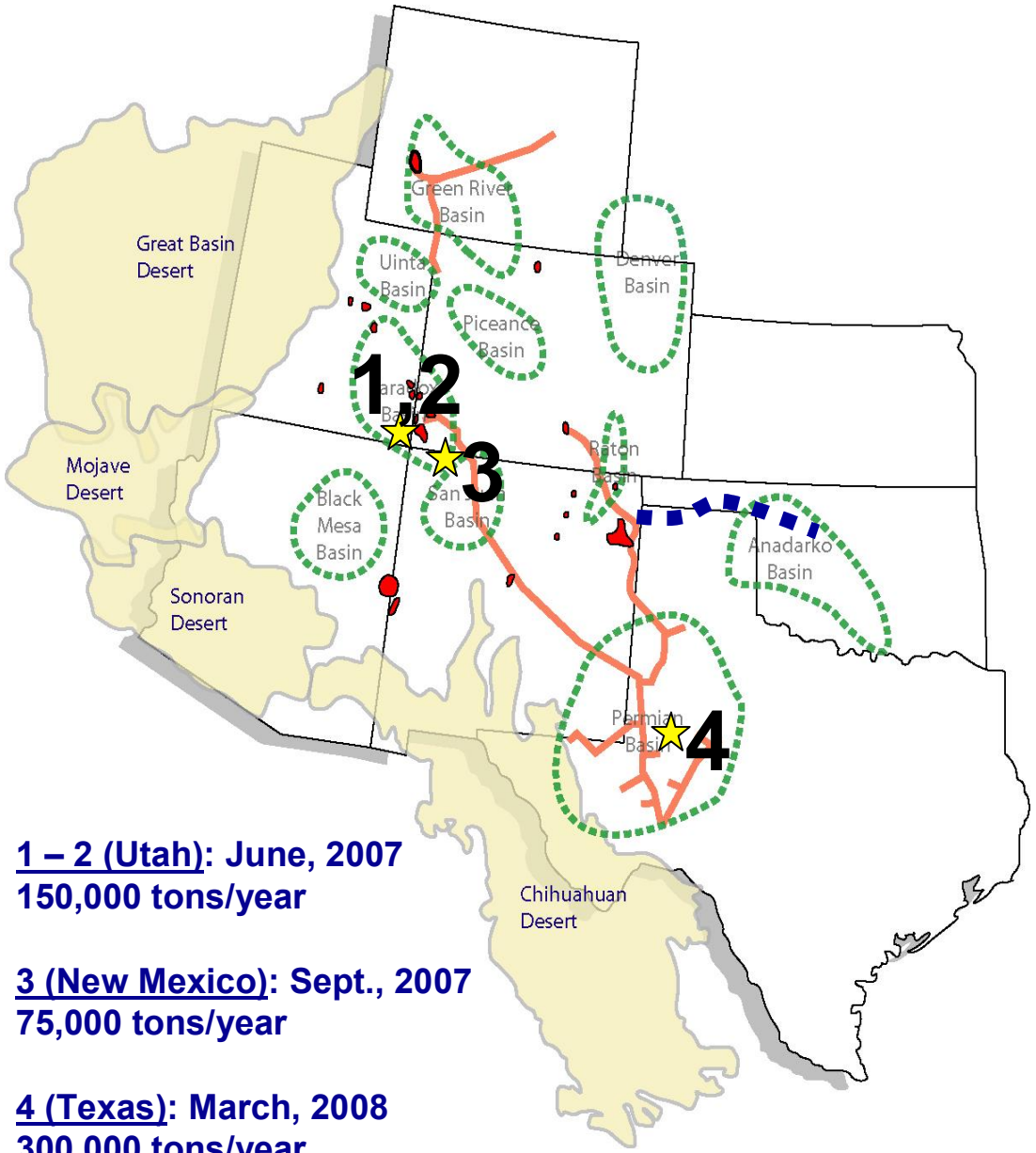


Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Phase II Portfolio



1 – 2 (Utah): June, 2007
150,000 tons/year

3 (New Mexico): Sept., 2007
75,000 tons/year

4 (Texas): March, 2008
300,000 tons/year

Four of over 100 geologic options were selected :

1) combined enhanced oil recovery with sequestration and

2) Deep brine reservoir sequestration testing, Paradox Basin, Utah

(3) combined enhanced coalbed methane production and sequestration testing, San Juan Basin, NM combined enhanced oil recovery and sequestration testing, Permian Basin, TX

(4) combined enhanced oil recovery and sequestration testing, Permian Basin, TX

Phase II Portfolio

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008

Phase II Demonstration Schedule

1 – 2 (Utah): June, 2007
150,000 tons/year

3 (New Mexico): September, 2007
75,000 tons/year

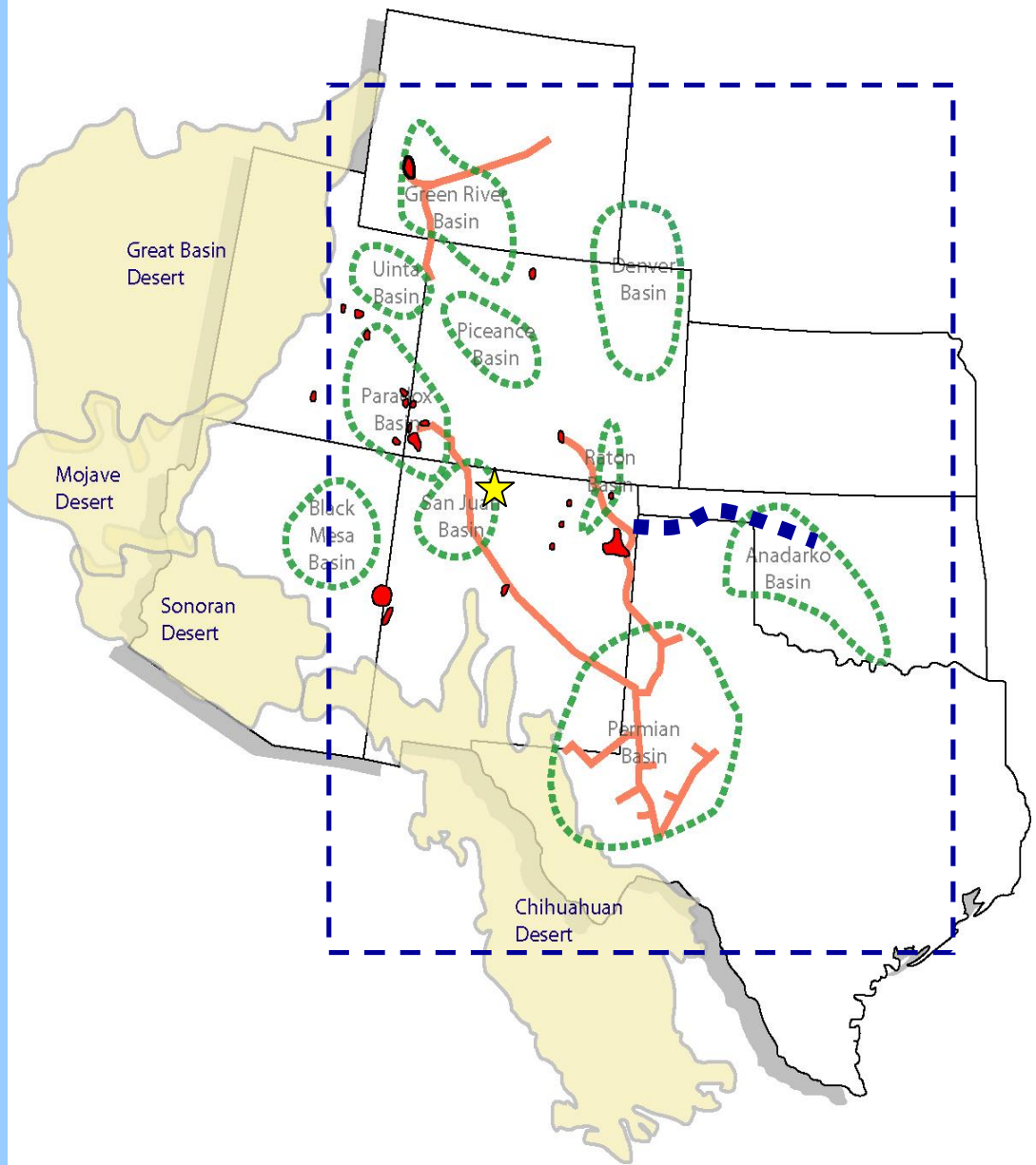
4 (Texas): March, 2008
300,000 tons/year

Phase II Portfolio

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008



<u>TERRESTRIAL</u>
Two terrestrial (surface vegetation) sequestration projects are ongoing in Phase II:

(1) Regional Assessment

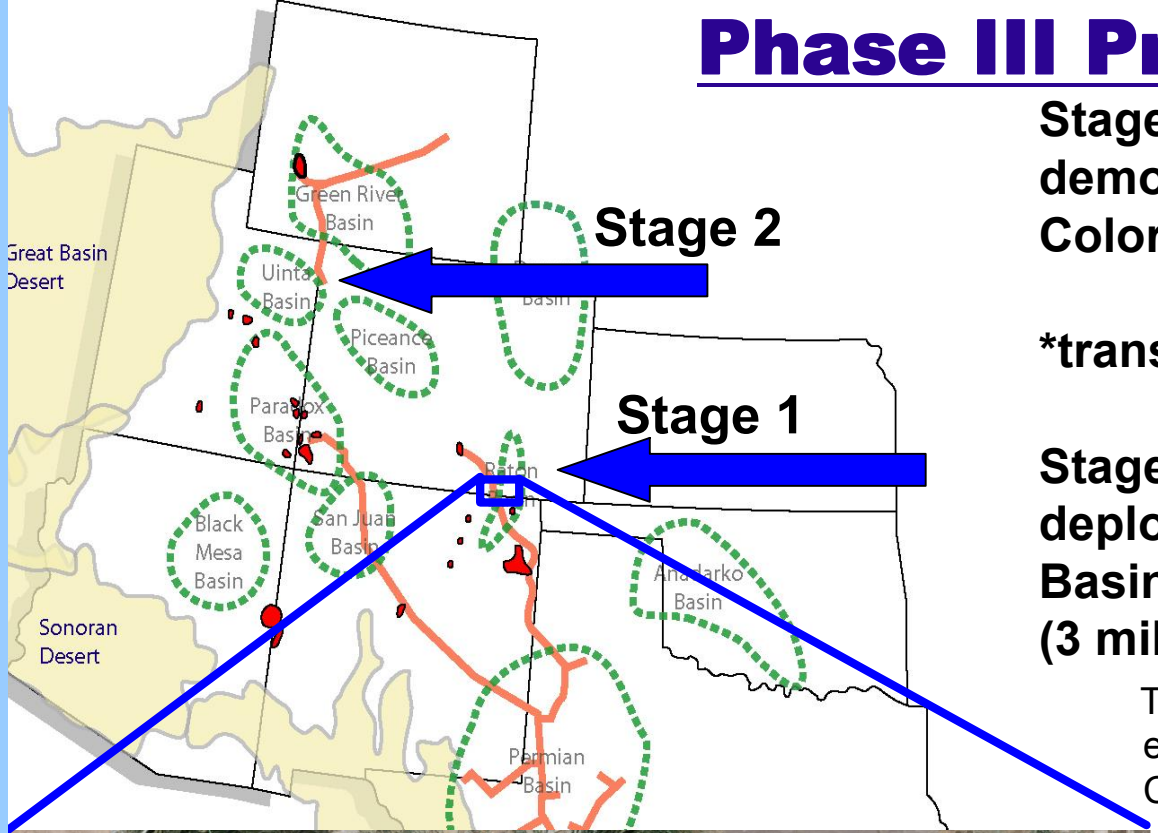
(2) A ~10 km scale pilot in New Mexico will be conducted in tandem with the ECBM sequestration pilot: produced water from the ECBM test will be desalinated and used to restore riparian lands.

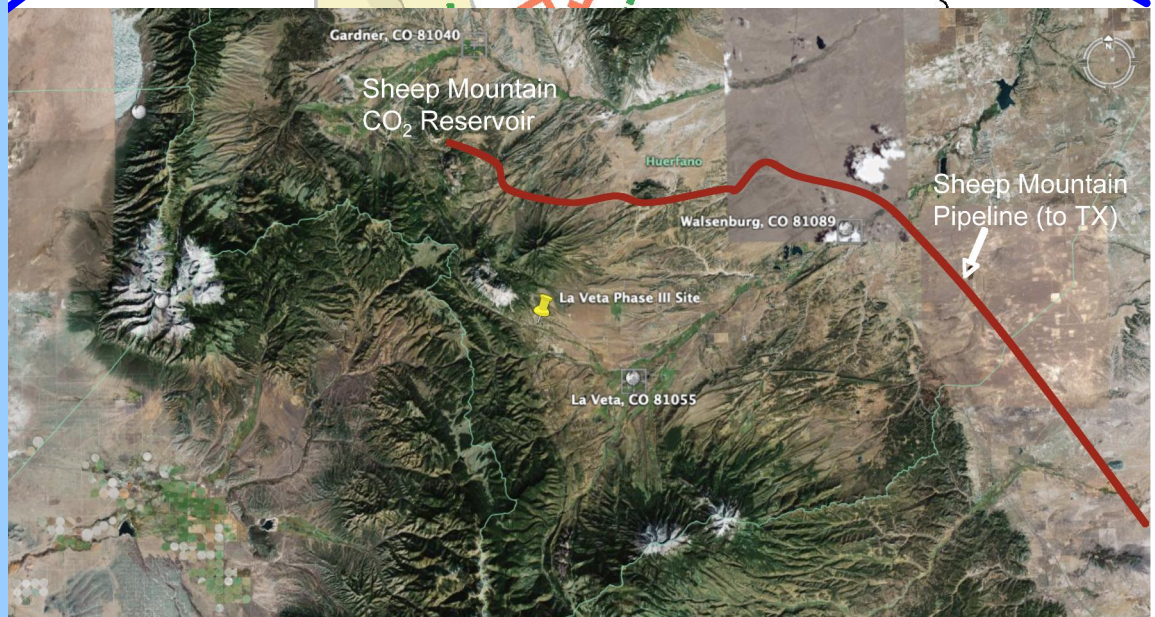
Phase III Project: 2008

Phase I:
2003-2005

Phase II:
2005-2009

Phase III:
Start 2008





Stage 1: Pilot demonstration in southern Colorado (1 million tons/y)

***transition* to**

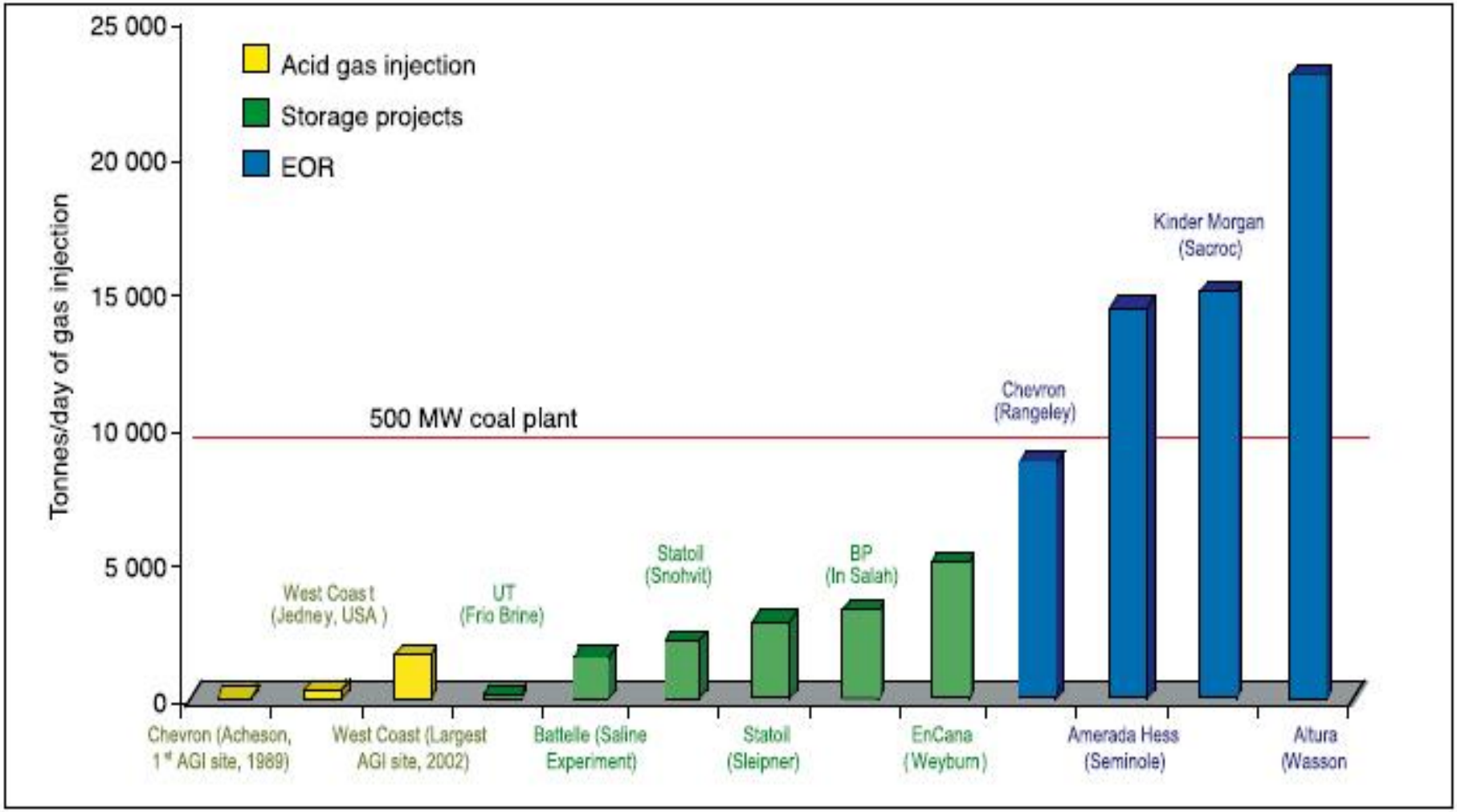
Stage 2: Commercial deployment in the Uinta Basin of northern Utah (3 million tons/year)

The area is blessed with an existing pipeline that can bring CO_2 from:

(a) A natural gas processing plant in southern Colorado
(b) A new ethanol plan in eastern New Mexico

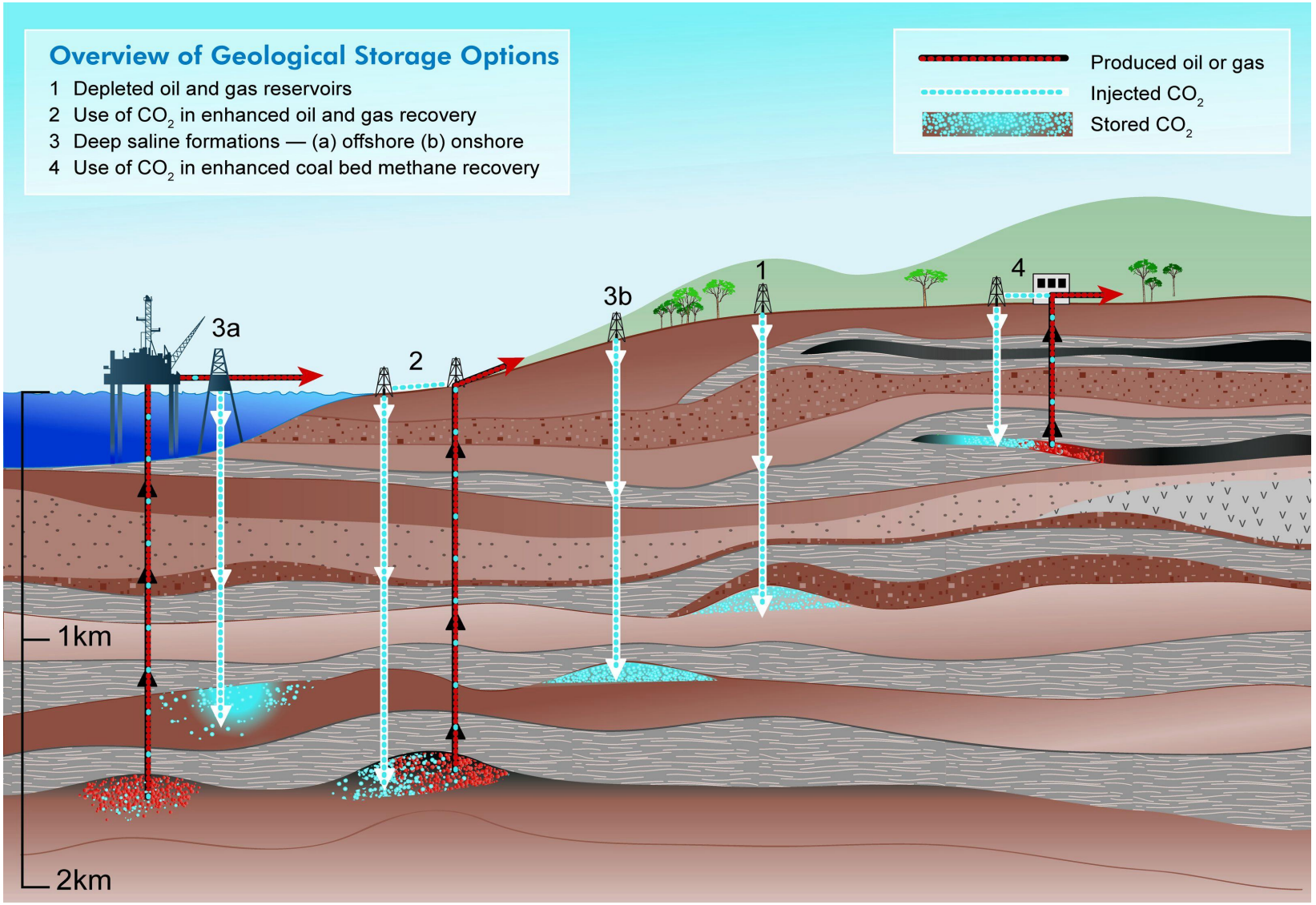
These combined sources will provide up to 1 million tons per year CO_2 , equivalent to a medium-size power plant, for the Phase III project in Colorado

Comparison of the magnitude of CO2 injection activities



(after Heinrich *et al.*, 2003).

Methods for storing CO2 in deep underground geological formations



SRCCS Figure TS-7

ICPP BANGKOK ACCORD! EGI

- UN Meeting of 120 nations
- Peak GHG by 2012
- We have 8 years to act
- Must limit to 2 deg. C rise next 30 years
- Need to reduce CO2 to 50-80% of 2000 levels
- Building energy efficient is important
- Last minute addition Nuclear power to overall strategy (a US push)
- Chinese and India question who pays (Developed Countries made the problem and should pay)

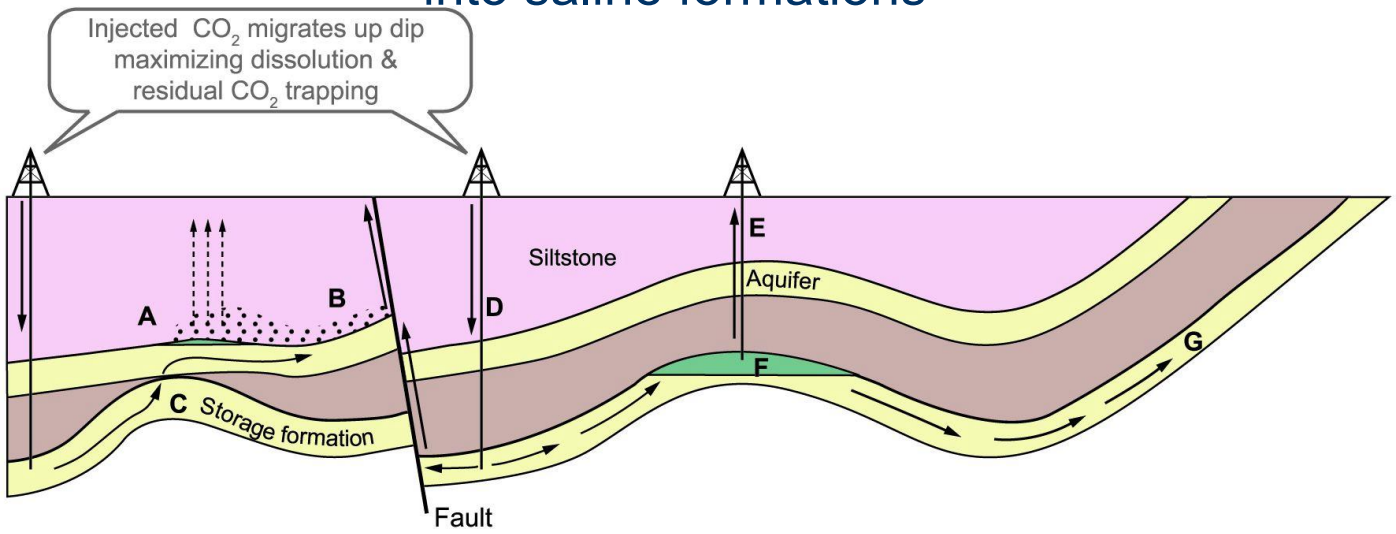
Last Slide

EGI

EGI…*the science to find energy*

EGI

Potential leakage routes and remediation techniques for CO2 injected into saline formations



Potential Escape Mechanisms

A. CO_2 gas pressure exceeds capillary pressure & passes through siltstone	**B.** Free CO_2 leaks from A into upper aquifer up fault	**C.** CO_2 escapes through 'gap' in cap rock into higher aquifer	**D.** Injected CO_2 migrates up dip, increases reservoir pressure & permeability of fault	**E.** CO_2 escapes via poorly plugged old abandoned well	**F.** Natural flow dissolves CO_2 at CO_2 / water interface & transports it out of closure	**G.** Dissolved CO_2 escapes to atmosphere or ocean

Remedial Measures

A. *Extract & purify ground-water*	***B.*** *Extract & purify ground-water*	***C.*** *Remove CO_2 & reinject elsewhere*	***D.*** *Lower injection rates or pressures*	***E.*** *Re-plug well with cement*	***F.*** *Intercept & reinject CO_2*	***G.*** *Intercept & reinject CO_2*

SRCCS Figure TS-8

EGI

Energy & Geoscience Institute
at the University of Utah

Overview for Pearl

EGI...*the science to find energy*

Calgary Houston **Salt Lake** London Sydney